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THE GREAT DROUGHT OF 1930 IN THE UNITED STATES

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[Weather Bureau, Washington, October, 1930]

This paper is chiefly concerned with the various aspects of the drought as a meteorological phenomenon. Unfortunately there is no yardstick by which one drought may be compared with another except at the cost of very great labor; even then in many cases the results would be unsatisfactory because the detailed records of previous droughts in this country have not been preserved in convenient form for reference.

The term "drought" is loosely used to mean any shortage of rainfall that may extend over an indefinite number of days without a quantitative scale as to the amount that shall be necessary to warrant the use of the expression "drought."

A search through the literature of the Weather Bureau reveals the fact that drought is defined in Circular M (fifth edition) Instructions to Marine Meterological Observers, as follows "Drought: A protracted period of dry weather."

Gen. A. W. Greely, the last military chief of the Federal weather service was the first to point out the need of a quantitative scale for use in connection with the term "drought." He suggested that that term be used only for those parts of the country where the average precipitation exceeds an inch in each month; he further remarked [1] that "from an examination of the records it appears that droughts are very severe whenever the rainfall for one or more months is less than 50 per cent of the average amount and it is suggested that the drought unit indicate a deficiency to be determined with reference to the average monthly amount during the time in which the drought prevails."

Henry [2] in 1906, proposed and used a definition of "drought" substantially as follows "Drought: A drought is considered to exist whenever the rainfall for a period of 21 days or longer, is but 30 per cent of the average for the time and place." That definition takes account of the fact that rainfall averages differ from place to place and from one season the of year to another.

In the Atlas of American Agriculture, section on precipitation, while the difficulties of formulating a definition of drought are fully set forth no effort seems to have been made to effect a compromise, since in the nature of the case an arbitrary definition without objection of one form or another is not possible.

The British Rainfall Organization defines "drought" as follows: "Drought, dryness due to lack of rain." According to the classification of that organization an *absolute drought* is a period of more than 14 days without one hundredth of an inch of rain on any day, and a *partial drought* is a period of more than 28 consecutive days, the mean rainfall of which does not exceed one hundredth of an inch per day or for the 28 days at most barely a quarter of an inch.

[1] Greely, A. W., American Weather, New York, 1888, p. 246.
[2] Henry, Alfred Judson, and others, Weather Bureau Bulletin, Q., Climatology of the United States, 1906, p. 54.

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The drought statistics compiled by Henry [3] show that scarcely a year passes, even in the more humid regions of the East without a more or less severe drought in some part of the United States according to the definition he adopted.

In the publication cited drought statistics for a single station, Washington, D. C., for the 33-year period 1871–1903, were published. Using the same method of compilation, the table there given has been brought down to date and appears below as Table No. 1. It presents a chronological list of droughts in Washington, applicable to adjacent areas on a uniform plan for 60 consecutive years.

TABLE 1.—*Periods of deficient rainfall at Washington, D. C., 1871–1930*

Year	Precipitation during 2 weeks previous to drought			Duration of drought	Number of days	Precipitation during drought		
	Amount	Normal	Percentage			Amount	Normal	Percentage
	Inches	*Inches*				*Inches*	*Inches*	
1871	3.0	1.6	188	From May 11 to May 31	21	0.1	1.4	7
	1.9	2.1	91	From Aug. 1 to 23	23	.7	3.0	23
1872	2.0	1.8	111	From June 17 to July 31	45	1.3	6.5	20
1873	4.8	1.7	282	From May 12 to June 27	47	1.4	6.2	23
	1.4	1.8	78	From July 2 to 26	25	.8	3.7	22
1874	3.0	1.8	167	From June 13 to July 9	27	.9	3.8	24
	2.0	2.0	100	From July 12 to Aug. 22	42	1.0	5.9	17
	5.8	1.7	341	From Sept. 20 to Oct. 31	32	.3	3.2	9
1875	1.4	1.6	88	From May 5 to June 4	31	.6	4.0	15
	1.5	1.8	83	From June 8 to July 14	37	1.4	5.2	27
	1.9	1.8	106	From Sept. 20 to Oct. 15	26	.6	2.8	21
1876	1.6	1.9	84	From June 29 to July 29	31	1.0	4.6	22
	3.5	1.6	219	From Oct. 2 to 22	21	.5	2.1	24
1877	2.2	1.9	116	From Aug. 14 to Sept. 5	23	.6	2.9	21
1878	3.9	1.8	217	From Sept. 14 to Oct. 17	34	.6	3.7	16
1879	3.2	1.8	178	From June 12 to July 24	43	1.1	6.2	18
	6.7	1.8	372	From Aug. 27 to Oct. 20	55	1.8	6.3	29
1880	2.9	1.8	161	From June 17 to July 19	33	1.0	4.8	21
	3.4	1.8	189	From Sept. 10 to Oct. 3	24	.5	2.8	18
1881	3.4	2.0	170	From July 9 to Sept. 9	63	2.0	8.6	23
	2.2	1.8	122	From Sept. 17 to Oct. 23	37	1.0	4.0	25
1882	3.6	1.8	200	From June 2 to 30	29	1.1	3.9	28
	2.7	2.0	135	From Aug. 3 to 25	23	.8	3.0	27
	4.4	1.7	259	From Sept. 28 to Oct. 31	34	.5	3.4	15
1883	3.5	2.1	167	From July 25 to Aug. 14	21	.7	2.9	24
1884	4.1	2.1	195	From Aug. 1 to Oct. 31	92	2.9	10.8	27
1885	3.7	1.7	218	From Sept. 6 to Oct. 1	26	.5	3.2	18
1886	6.0	2.0	300	From Aug. 2 t Aug. 29	28	.3	3.6	6
	1.9	1.8	106	From Sept. 10 to Oct. 25	46	1.2	5.0	24
1887	1.7	1.9	89	From Aug 13 to Sept. 10	29	.7	3.6	19
	1.2	1.7	71	From Sept. 29 to Oct. 19	21	.4	2.1	19
1888	2.8	1.8	156	From June 1 to 22	22	.8	2.9	28
	3.9	2.1	186	From July 14 to Aug. 7	25	.9	3.6	25
	5.8	1.8	322	From Sept. 19 to Oct. 18	30	.7	3.2	22
1889	6.4	2.0	320	From Aug. 10 to Sept. 11	33	.9	4.2	21
1890	1.9	1.8	106	From June 24 to July 23	30	.9	4.0	22
1891	3.0	2.1	143	From July 30 to Aug. 20	22	.7	3.1	23
	5.2	1.8	289	From Sept. 7 to Oct. 18	42	.8	4.6	17
1892	3.4	1.8	189	From May 28 to June 26	30	1.0	4.0	25
	2.9	2.1	133	From Aug. 1 to Sept. 12	33	1.0	5.5	18
	3.4	1.7	200	From Sept. 24 to Oct. 21	38	.3	3.9	8
1893	2.3	1.8	128	From June 3 to Aug. 3	62	2.5	8.8	28
1894	2.2	1.8	122	From May 24 to July 21	59	1.8	8.2	22
	2.4	2.0	120	From Aug. 5 to Sept. 16	43	1.5	5.5	27
1895	2.2	2.0	110	From July 29 to Oct. 30	94	3.1	11.1	28
1896	1.2	1.8	67	From June 15 to July 5	21	.8	2.9	28
	2.3	2.1	110	From July 23 to Aug. 12	21	.7	2.9	24
	2.1	1.7	124	From Sept. 6 to Oct. 31	56	1.8	6.1	30
1897	2.3	1.9	121	From Aug. 12 to Sept. 22	42	1.3	5.3	25
1898	3.3	1.8	183	From May 17 to July 17	62	2.1	8.5	25
	8.3	1.9	437	From Aug. 14 to Oct. 17	65	1.9	7.6	25

[3] Loc. cit. pp. 52–56.

TABLE 1.—*Periods of deficient rainfall at Washington, D. C., 1871–1930*—Continued

Year	Precipitation during 2 weeks previous to drought			Duration of drought	Number of days	Precipitation during drought		
	Amount	Normal	Percentage			Amount	Normal	Percentage
	Inches	*Inches*				*Inches*	*Inches*	
1899	1.6	1.8	89	From June 13 to July 4	22	.9	3.0	30
	3.2	1.9	168	From Aug. 16 to Sept. 10	26	.6	3.3	18
1900	7.0	1.8	389	From June 18 to Aug. 19	63	2.1	8.9	24
	1.7	1.8	94	From Aug. 25 to Sept. 14	21	.5	2.7	19
1901	4.5	2.1	214	From July 15 to Aug, 5	22	.7	3.2	22
	2.4	1.8	133	From Aug. 25 to Sept. 27	34	.9	4.2	21
	1.2	1.6	75	From Oct. 4 to 31	28	.6	2.8	21
1902	2.4	1.8	133	From May 26 to June 15	21	.7	2.7	26
	3.0	2.1	143	From June 27 to July 17	21	.8	3.1	26
	2.1	2.1	100	From Aug. 7 to Sept. 2	27	.6	3.4	18
1903	2.1	1.7	124	From Aug. 31 to Oct. 6	37	1.2	4.4	27
1904	4.5	2.5	184	Aug. 3 to Sept. 13	42	1.2	5.4	23
	5.0	1.8	287	Sept. 16 to Oct. 20	34	.6	3.4	18
1905	2.2	1.7	123	Sept. 12 to Oct. 10	30	.2	3.4	6
1906	2.8	1.7	165	Apr. 16 to May 26	41	.8	4.7	16
	8.5	2.0	425	Sept. 1 to Sept. 30	30	.6	3.6	17
1908	1.6	1.7	94	Apr. 12 to May 3	22	.6	2.3	26
	1.6	2.0	180	June 16 to July 20	38	.6	4.8	12
	5.9	1.5	393	Sept. 7 to Sept. 27	21	0	2.7	0
	1.6	1.8	89	Sept. 29 to Oct. 28	29	.5	2.8	18
1909	2.4	1.9	126	Sept. 25 to Nov. 22	59	.9	5.6	16
1910	1.1	2.3	48	Aug. 1 to Aug. 31	31	1.3	4.4	29
	1.7	1.9	90	Sept. 7 to Oct. 6	28	.5	3.4	15
1911	1.5	1.4	93	Apr. 23 to May 29	37	.2	4.3	5
1912	3.0	2.3	130	Aug. 1 to Aug. 28	28	1.1	3.8	29
	3.2	1.6	200	Oct. 1 to Nov. 6	37	.9	3.7	24
1914	2.0	1.4	143	Apr. 27 to May 26	30	.9	3.6	25
	.7	1.8	41	May 28 to June 18	21	.8	3.1	26
	4.2	1.8	233	Aug. 30 to Sept. 30	32	.7	3.8	18
1915	.7	1.5	49	Apr. 13 to May 11	29	.2	3.1	7
1917	.9	1.6	55	Sept. 9 to Oct. 4	26	.5	2.8	17
1918	2.6	2.1	125	Sept. 22 to Oct. 29	38	.5	3.6	14
1921	1.4	1.9	74	June 1 to June 25	25	.5	3.5	14
	1.1	2.2	50	July 30 to Sept. 1	34	1.1	4.9	22
1922	1.2	1.2	100	Oct. 11 to Nov. 30	51	.7	3.9	18
1923	1.8	2.1	86	Sept. 24 to Oct. 21	27	.5	2.8	18
1924	2.8	2.0	140	July 10 to Aug. 8	29	.6	4.8	12
	6.8	1.6	428	Oct. 1 to Nov. 14	45	.5	4.3	12
1926	1.2	1.8	67	Apr. 1 to May 13	43	.8	4.8	17
1929	2.4	1.8	134	July 2 to Sept. 4	65	2.0	9.3	21
1930	2.8	1.4	200	Apr. 19 to May 13	24	0	2.7	0
	1.4	1.9	74	July 16 to Oct. 31 [1]	115	2.6	14.8	18

[1] The drought in Washington, D. C., and surrounding areas in Maryland and Virginia, had not been broken on this date.

The economic results of drought can not always be measured by the shortage in rainfall alone, hence the interpretation of the figures in the table is not easy. It is obvious that a deficiency amounting to 70 per cent of the normal rainfall in regions of abundant precipitation is not as serious as a deficiency of the same amount in places where the total rainfall is barely sufficient for the growth of staple crops.

The moisture content of the soil at the beginning of the drought is always an important consideration; there are added, to the table, therefore, figures showing the amount of rain that fell in the two weeks immediately preceding the drought. These figures are quite significant in the interpretation of the severity of the drought in each case.

It is a rather striking fact that for the years 1871–1903 51 out of a total of 62 cases had from 100 to 200, 300, and in extreme cases 400 per cent of the normal rainfall in the two weeks immediately preceding the beginning of the drought.

It is a matter of regret that time did not permit the examination of each individual case in order to determine the nature of the rains, whether as daily showers for several days or as a single torrential rain. If the latter then much of the rain would become surface run-off and be lost as a stimulus to vegetable growth.

Considering the whole period of 60 years covered in Table No. 1 it will be seen that in 69 out of the total of 93 droughts the rainfall immediately preceding them was 100 or more per cent of the normal for the time and place. That number is considerably greater than would be indicated by chance alone. The apparent explanation is that a long-continued showery period or a single torrential rain exhausts the moisture content of the atmosphere for the time and place to such an extent that further precipitation becomes more and more difficult until a fresh supply of saturated or nearly saturated air is brought in.

Examples of very great contrasts between the rainfall of short periods of time are numerous, only one will be given. In the two weeks prior to July 16, 1874, 7.4 inches of rain fell at Vicksburg, Miss., and in the 69 days immediately following the total fall was but 0.8 inch.

The longest period of deficient rainfall of which notice has been taken occurred at Shreveport, La., from June 14 to October 31, 1883, when the total rainfall for 141 days was but 22 per cent of the normal.

The distribution of deficient rainfall periods by months is given below for the two periods 1871–1903 and 1904–1930.

	1871–1903	1904–1930
	Per cent	*Per cent*
Number that began before Apr. 15	2	10
Number that began between Apr. 16 and May 15	10	13
Number that began between May 16 and June 15	13	6
Number that began between June 16 and July 15	17	10
Number that began between July 16 and Aug. 15	20	19
Number that began after Aug. 15	38	42

CAUSES OF THE DROUGHT

Very few persons realize the difficulty of attempting to analyze the cause or causes of prolonged heat and drought. While they may have a common cause it can not be said that the one is the cause of the other; this can be said however, viz, that drought has a tendency to perpetuate itself and high temperature is a valuable adjunct.

Percentage of normal rainfall, 1930

States	January	February	March	April	May	June	July	August	September	January to September	March to August	July and August
Kentucky	112	101	46	33	73	*42*	*30*	60	86	*63*	*47*	*45*
Maryland and Delaware	82	68	59	74	62	83	*37*	*26*	44	*58*	*55*	*31*
Virginia	80	48	56	67	65	77	*39*	*40*	41	*56*	*56*	*39*
Missouri	221	81	45	53	73	79	*24*	54	109	75	*57*	*39*
Illinois	208	104	48	79	46	87	*31*	57	101	78	*58*	44
Indiana	209	98	47	73	45	68	52	63	116	82	*58*	*57*
West Virginia	49	85	82	55	56	*64*	*42*	54	48	*59*	*59*	*48*
Ohio	162	110	81	65	50	60	*40*	68	91	77	*60*	53
Louisiana	166	78	78	29	132	*13*	61	89	180	89	66	74
Arkansas	223	117	47	*29*	200	*22*	*19*	70	121	95	68	*44*
North Carolina	94	33	65	59	76	98	62	50	90	69	68	56
Tennessee	105	94	89	37	134	*33*	54	65	106	*79*	69	59
Pennsylvania	68	101	86	80	76	102	51	*35*	72	*73*	*71*	*43*
Michigan	118	104	75	71	96	109	47	27	69	77	71	37
Alabama	88	43	98	34	96	46	73	77	196	80	72	75
Mississippi	107	69	71	23	208	*13*	52	74	156	81	72	62
South Carolina	125	26	86	70	68	91	82	42	110	76	72	62
North Dakota	54	241	*11*	91	103	88	40	64	62	76	73	51
Montana	57	82	103	121	59	58	68	90	114	79	76	77
Oregon	68	104	55	97	123	61	11	43	96	82	76	28
Minnesota	88	171	44	53	136	94	71	*34*	120	87	77	54
New Jersey	81	78	66	64	74	113	86	67	56	76	78	77
Texas	99	82	84	60	141	66	41	59	67	78	78	50
Washington	46	129	79	91	105	92	11	24	80	82	80	18
South Dakota	88	101	50	100	90	77	34	118	76	80	80	72
Iowa	125	55	50	90	81	130	39	70	63	79	81	54
Oklahoma	173	97	27	80	136	93	38	59	65	84	81	49
Wisconsin	94	120	74	79	91	133	70	32	84	85	82	52
Georgia	118	32	121	91	65	87	100	36	173	88	84	70
Kansas	148	27	20	109	115	98	60	92	104	90	89	75
California	97	65	85	92	134	10	22	80	100	86	90	53
New York	107	63	117	70	103	117	76	63	84	88	90	69
New England	79	64	127	50	107	102	102	66	48	83	92	83
New Mexico	117	37	98	58	99	76	132	86	68	91	97	110
Idaho	71	120	84	114	131	66	54	181	114	101	103	120
Nebraska	140	54	38	150	145	85	45	147	77	102	106	92
Colorado	155	68	67	57	134	49	140	160	72	103	107	149
Wyoming	95	82	90	55	108	70	90	331	61	103	112	191
Florida	126	99	241	131	105	159	*62*	62	126	115	113	*62*
Utah	134	84	77	69	129	74	121	214	162	119	115	172
Nevada	128	75	67	101	256	32	43	182	214	121	122	119
Arizona	174	41	181	65	269	118	144	103	80	123	135	124
United States [1]												
Average precipitation	2.6	1.7	2.0	1.8	3.2	2.3	1.8	2.0	2.7	20.1	13.1	3.8
Normal	2.3	2.2	2.4	2.5	2.9	2.9	2.8	2.6	2.4	23.0	16.1	5.4
Percentage of normal	113	77	83	72	110	79	64	77	112	87	81	70

[1] State means weighted by respective areas.

Italic figures indicate least precipitation of record.

The present shortage of rain began in December, 1929; that shortage, however, was in no wise different in magnitude or geographic distribution than occurs practically every year in some part of the country. No one could foresee at the time that the drought would continue for 10 months and spread to every State east of the Rocky Mountains except Florida.

Table 1 and the text up to the paragraph beginning "In searching for" is reprinted from Weekly Climate and Crop Bulletin of October 14, 1930.

PRECIPITATION IN THE UNITED STATES, FROM JANUARY TO SEPTEMBER, 1930

The table above summarizes, by months and other periods, precipitation data for the United States from January to September, inclusive, of the current year. The data represent final and complete figures for all stations maintained by the Weather Bureau, some 5,000 in number, except that in the case of September a few late reports may make slight changes in the State means. The table is arranged relative to deficiencies in precipitation for the spring and summer combined, March to August. It also includes a summary for the country, as a whole, obtained by weighting the respective State means on a relative area basis; these represent very closely the true means for the entire country. *Italic* figures indicate in all cases the least precipitation of record for the month or period.

Considering the New England States as a unit, and also Maryland and Delaware, the data represent 42 States. Of these, only 19 had deficient precipitation in January, with no previous low records broken. In February, 29 States had precipitation below normal, with no new low records. In March, 36 had means below normal, with one previous low record, North Dakota, broken. In April, 35 States had less than normal rainfall, with Arkansas alone having the lowest of record. In May, rainfall was generally greater, with only 20 States, or less than half the total number, having deficiencies, and no new low records established.

June was much drier than May, with 33 States reporting deficiencies in precipitation, and 6, Arkansas, Kentucky, Louisiana, Mississippi, West Virginia, and Tennessee, exceeding the previous low records. July was the driest of the nine months, with the rainfall in 36 States deficient, and Virginia, Maryland, West Virginia, Kentucky, Ohio, Illinois, Missouri, Florida, and Arkansas having the least of record. In addition, July was extremely warm in most sections. Every State had maximum temperatures of 100°, or higher, with the previous high records broken in Alabama, Florida, Indiana, Kentucky, Maryland, Mississippi, Tennessee, Virginia, and West Virginia, and equalled in Louisiana, New Mexico, and South Carolina. On the other hand, minimum temperatures were low in some States, with freezing, or below, reported in 11 of the 42.

In August, 35 States had deficient precipitation, with Virginia, Maryland, Pennsylvania, and Minnesota having the lowest of record. The first half of this month continued warm, and again every State had maximum temperatures of 100°, or higher; there was also some abnormally cool weather, with 19 of the 42 States reporting minimum temperatures of freezing, or below, and in one case as low as 10° below freezing. In September, much of the droughty area of the interior of the country was relieved, but, at the same time, 24 States had less than normal rainfall, though no previous low records were broken.

For the country, as a whole, January, with 113 per cent of normal rainfall, was relatively the wettest month, but was closely followed by September and May, with 112 and 110 per cent, respectively. All other months had deficient rainfall. July was the driest, with 64 per cent of normal, followed by April, with 72 per cent, and February and August, with 77 per cent. The records of normal rainfall for the country, as a whole, show a quite uniform monthly distribution for the nine months, the maximum being 2.9 inches for May and June and the minimum 2.2 inches for February.

For the entire period, April to September, West Virginia, Maryland, Virginia, Kentucky, Pennsylvania, and Tennessee had the least rainfall of record, while Ohio and Michigan had the least since 1895, and Missouri since 1901. In the case of West Virginia, the seasonal total was 35 per cent below the previous low record; in Maryland, 22 per cent; Virginia; 18 per cent, and Kentucky, 13 per cent. For the spring and summer months combined, March to August, the table shows that nine States had the least rainfall of record, while eight broke the previous low record for July and August combined.

In searching for pronounced abnormalities of the weather in distant regions that may or may not have contributed to the drought in continental North America, attention is first directed to a persistent and rather pronounced depression of the barometer over the northeastern North Atlantic Ocean, that prevailed from October, 1929, to February, 1930, as illustrated by the readings at Lerwick, Shetland Islands, and the west coast of Ireland as at Valencia. The upper half of the North Atlantic was exceptionally stormy during the first and third decades of December, 1929, as might be expected from the persistent low pressure at Lerwick and Valencia.

Considering now the pressure distribution over the northeastern North Pacific for the same month it is to be noted that while the reverse pressure conditions prevailed over the first half of the month, the high pressure gave way to very low pressure 28.76 inches at Dutch Harbor on the 27th and 28.82 at Kodiak on the 28th. The Aleutian LOW in January, 1930, was displaced far to the south-southwest and high pressure prevailed over the northeastern North Pacific and coastal Alaska, Kodiak 0.56 inch above normal and Juneau 0.45, a complete reversal from conditions in January.

The high pressure over northeastern Pacific doubtless was directly related to the development of a large number of anticyclones over the western Canadian provinces and their subsequent movement southeastward over the United States and likewise of the development and movement of a group of cyclones from British Columbia and the State of Washington southeastward to various points west of the Mississippi, thence northeastward to the Great Lakes and down the St. Lawrence Valley.

When cyclones recurve to the northeast east of the Mississippi generous precipitation is assured to Atlantic coast districts but cyclonic storms passing down the St. Lawrence Valley may or may not yield generous rains to the piedmont section of Atlantic seaboard States. In January, 1930, there was more or less failure of the rains from the Carolinas northward to New England; thus in a rather devious path we relate the failure of the rains in the beginning of the drought to the course and character of the cyclonic storms which passed across the country.

The change in pressure from January to February, 1930, was exceptionally large; whereas high pressure prevailed in January it gave way remarkably to low pressure in February and with the low pressure an unusually large crop of cyclonic storms most of which entered the continent north of 50° north latitude and moved eastward at or north of the Canadian boundary. As a result the warmest February, perhaps in a century, was experienced in the United States. With the exceptional heat there was much dryness and it is perhaps not far from the truth to ascribe the beginning of the drought to the disturbed condition of the general circulation that set in in that month. The succeeding months, March to June, were not especially dry except in rather small areas; North Dakota, for example had but 11 per cent of its normal rainfall in March. The most noticeable phenomenon was the breaking down of the cyclonic part of the secondary circulation and perhaps in one or two months the intensification of the circulation induced by anticyclones. The latter was especially noticeable in the piedmont sections of the States south of the Pennsylvania line. In these States it was doubtless the largest single factor contributing to the failure of the rains.

Anticyclones mostly from the Hudson Bay region drifted southward and settled over the Carolinas, Virginia, and Maryland thus insuring to those States at least a week of uninterrupted sunshine before the high pressure would pass away; moreover, the presence of high pressure over the Atlantic off the Carolina coast with the wedge-shaped front extending westward across the Appalachians doubtless diverted the paths of cyclonic storms approaching from the West into a more northerly course, thus withholding from the Virginia-Maryland region the rains that were received by States farther westward. Still another condition the reason for which is not known persisted, viz, cyclonic storms moving northward along and a short distant offshore failed to give rain in coastal States until the New Jersey coast was reached.

In September the weather control was mostly anticyclonic with no cyclones of importance, except, possibly on two occasions, the 23d and 26th; on the first named a cyclonic storm with circular isobars and central pressure down to 29.10 inches moved north-northeast from Montana to Manitoba with a further fall of pressure to 29.05 inches. A secondary from this cyclone developed over Colorado and moved thence to Wisconsin central pressure falling to 29.16 inches. This storm was attended by considerable precipitation in the Lake region and Ohio Valley, but the center of the cyclone continued to move northward to Hudson Bay in the ensuing 24 hours with no rain in the Carolinas and thence to southern New England. High pressure followed closely in the wake of the cyclone.

CONCLUSION

The secondary circulation, especially that branch which is associated with air movement about cyclonic systems, became weak and disorganized during the spring and early summer months of 1930. By midsummer a blanket of warm surface air had developed over the great interior valleys extending from the Gulf of Mexico to the Canadian border in which the normal temperature gradient with latitude had been destroyed.

Beginning with the turn of the season in September, when the transfer of polar air equatorward normally sets in, the chief weather control as between cyclones and anticyclones passed definitely to the anticyclones. In September, 1930, anticyclones from the Hudson Bay region moved south-southeast and merged with the semi-permanent high pressure over the Atlantic some distance east of the Carolina coast. In that position they served as a buffer to prevent cyclonic systems from moving up the Ohio Valley and spreading across the Appalachians into Atlantic coast States. The effect of this control was to augment the tendency of the dry weather to maintain the status quo in the piedmont sections of Atlantic coast States where drought still endures.

WEATHER CONDITIONS AS FACTORS IN THE FILTRATION OF THE WATER SUPPLY AT DETROIT, MICH.[1]

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Weather conditions are the most important single factor necessitating variations in the purification process in the Detroit water supply. Winds reaching from 20 to 30 miles per hour, for a few consecutive hours, tend to stir up the waters of shallow Lake St. Clair, lap the shores and gather pollution from them and their populous hinterland, with the result that at the filtration plant there is an increase in the turbidity, increased bacteria, and likewise increased *B. coli*. Thaws in winter cause ice to break loose from shores and streams to swell with polluted waters, bringing great quantities of sewage to the lake and water intake. Rainstorms flush out tributaries to Lake St. Clair, and in the spring, the break-up of ice in the upper Lakes produces much pollution. The intake for the water supply is located at the head of Belle Isle, near the outlet of Lake St. Clair. The area of Lake St. Clair is 460 square miles; no place in it is more than 22 feet deep, and therefore it is easily stirred up. Numerous tributaries drain to it from a populous land along its borders and the St. Clair River. The largest of these tributaries are Fox and Conners Creeks, entering a short distance above the intake. These creeks have given cause for great pollution in the past, but now their flow is intercepted and sent southward under Jefferson Avenue, paralleling the river, and making exit to the river some 4 miles below the intake. (Figs. 1 and 2.)

Evidences of the influences of the various conditions of weather can be seen best when charted with filtration records. The following study will show in the order named a case of the influence of the wind, the influence of wind when the lake is ice covered, the influences of wind and back flow of the river, rainstorms, thaws, and lastly a case of the influences of a combination of weather conditions on the filtration process.

Wind as a factor influencing filtration is illustrated by the storm of December 8, 1928. This storm developed from a well-marked LOW which passed eastward as most low-pressure areas do in the United States. This particular low passed slightly north of Michigan, and on the weather map of December 8, was centered about 200 miles north of Georgian Bay and was well-developed. A fairly well marked HIGH was located at the same time in Texas, and as is the case when well developed HIGHS and LOWS are so close to each other, the pressure gradient was steep (1.7 inches difference). The wind velocity reached a maximum of 60 miles per hour from the southwest at Detroit during the early morning of December 8. The direction shifted to the west for a few hours near midnight on December 8, but returned to the southwest,

[1] This article is an excerpt from a doctor of philosophy dissertation submitted at Clark University, Worcester, Mass. in April, 1930.